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A Case of Survival of a Goldfish Following the Loss of Its Tail

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(Plates I & II)

There are a considerable number of references to accounts of the finding of living and active fishes which have survived the loss of tail and caudal trunk. In the more extreme cases this loss has reached almost to the body cavity. Reports of such accidents are distributed among the groups of fishes as follows:

Isospondyli	
Tarpon atlanticus	Nichols (1921)
Salmo irideus	Nusbaum (1907)
Ostariophysi	
Piabucina festae	Breder (1927a)
Cyprinus carpio	Fiebiger (1907) Nusbaum (1907) Tarnani (1911)
Scardinius erythrophthalmus	Breder (1927b)
Haplomi	
Esox lucius	Hofer (1901)
Acanthopterygii	
Trachinotus falcatus	Breder (1934)
Epinephelus guttatus	Breder (1934)
Plectognathi	
Meuschenia skottowei	Pope (1945)

It is likely that a considerably greater number of examples are hidden in the literature, in papers whose titles give no hint of some incidental mention of them.

The accounts all agree in one respect, which is that all the fishes have been found in a state of complete recovery. The present account describes a similar case in a goldfish, *Carassius auratus* (Linnaeus), but in which the date of the mutilation is known and in which the fish was under continuous observation during the entire time of recovery. It concerns a fish kept with others in an outdoor pool under essentially natural conditions over a period of years. These fish were subject to a certain amount of predation from occasional marauding kingfishers, herons, bullfrogs and garter snakes, but usually the predation was of no serious nature.[1]

On July 17, 1952, it was found that one of the goldfish in the larger of the two pools had suffered the removal of its tail at a location sufficiently anterior to cut through the dorsal fin. The cut was lunate and clean, as though made by some more-or-less hard-mouthed creature such as a snapping turtle. It was difficult to imagine that any bird beak could have been responsible. Whatever did it was never discovered and is still a matter of some speculation. The first thought was to destroy the fish, but even without its tail, it wagged the stump with sufficient vigor to elude easy capture. During the ensuing period it clearly avoided the other fishes, which generally kept in a fairly well integrated aggregation. Likewise the intact individuals paid no attention to the injured one and, if anything, seemed to avoid it in return. This could be interpreted perhaps as an avoiding reaction to homotypic body fluids similar to that studied by von Frisch (1938, 1941a,b) on *Phoxinus*.

Five days later, on July 22, the dead and whitish tissue about the wound had sloughed off and the wound appeared smooth and rather pinkish. Evidently it was now covered with epithelium and perhaps erythrophores were developing. At this time, the fish returned to the aggregation and ran with the others. With the tail gone, it tended to be

[1] A discussion of the situation of these pools, in which they are described in connection with other work, is given by Breder (1946).

lighter toward the rear so that when at rest it would point downward. This was overcome by appropriate pectoral paddling, except when the stump was waved, which activity drove the fish straight forward. After another eight days, on July 30, muscular tension evidently tended to draw the wound together. This operated to pull both dorsal and anal inward so that some of the rays of both fins pointed straight back, making for more efficient locomotion. This is, of course, typical of most such injuries, as has been repeatedly shown by the literature previously listed.

By September 7, 53 days after the injury, the positions of the vertical fins were in their final place and from then on there was no evident change (Pl. I, Fig. 1). This fish spent more time "standing on its nose," working over bottom materials, than the rest, which may have been associated with greater ease in maintaining that position because of the new conditions of equilibrium. There was no evident adjustment to this new condition of equilibrium by the swim bladder, the fish to the last maintaining a horizontal position only by pectoral fin activity.

In this colony of fishes there was another one almost identical in size and appearance to the injured one. As considerable growth was shown by these fishes during the period, it is noteworthy that the injured one kept pace with its similar-sized fellow, the damage apparently not reducing its speed of growth sufficiently to be readily noticeable.

This entire process of healing a major wound took place at the speed indicated at temperatures mostly below 20° Centigrade. On the day of the accident the temperature in the pool varied from 21° to 22° and on the three days following it twice reached 23° in the middle of the day. Following this the temperature fell and continued low on into August because of the lush growth of shade trees, being mostly below 20° to a low of 18°. Only on two warm days during August did highs of 22° occur. The fishes were removed to indoor aquaria for purposes of wintering on October 4, when everything seemed to be in a satisfactory condition. Four days later the tailless fish was found freshly dead, for no evident reason.

A radiograph (Pl. II, Fig. 3) showed that the spinal cord had been severed at the level of the fourth caudal vertebra, the neural spine of which was missing although the haemal spine remained. Since goldfish have about 14 caudal vertebrae, evidently about 10 had been amputated. The anal fin was intact, as can be seen by the presence of the characteristic final double ray. The similar final dorsal ray was missing, but evidently few if any more had been lost, as the fish had 16 soft dorsal rays remaining while the species usually has 17. Since the end of the dorsal base is generally over the eighth caudal vertebra, and the end of the anal base under the tenth, the curved nature of the bite is nicely plotted from a point just posterior to the anal fin through the fourth caudal vertebra to between the last two dorsal rays. The shape of the bite passing through these points on a normal fish (Pl. II, Fig. 4) indicates why it was thought that the predator was probably a turtle. By a comparison with other goldfish based on proportional measurements, the fish must have been very close to 130 mm in total length before the accident, actually calculated as 128 ± 12 mm. Considering the shape and size of the bite, it would require an animal with a gape not less than about 20 mm wide, and by nature of the clean knife-like wound it would seem almost certain that the animal was a marauding snapping turtle since no other animal in the region combines these characteristics of size and shape of mouth, actually calculated as 19 ± 1 mm even when some allowance is made for the growth of the fish. This kind of behavior on the part of *Chelydra* was not previously known to occur here, but there is an old ice pond not more than five hundred feet distant in which snapping turtles occur. Probably the gape was much wider than 20 mm, which it could easily be and still pass through the required skeletal points noted, as the mouth must have been capacious enough to take in about 56 mm of peduncle and tail fin, actually calculated as 56 ± 12 mm, which eliminates all the smaller turtles of the region. Even if the tail passed out one side of the mouth, as on a basis of the position of the curve (Pl. II, Fig. 4) it might have, the situation would still call for a deep cleft jaw.

The accident occurred between 8:45 a.m. and 1:00 p.m., as the fish was seen intact at the earlier hour and in the wounded condition at the later hour. It was thus clearly not some night prowler that was responsible.

The change in the swim bladder is perhaps the most striking alteration shown by the radiographs. The posterior chamber has been completely suppressed, but as already noted this was insufficient for perfectly normal equilibrium. Autopsy showed that the posterior chamber of the swim bladder had lost all its gas, and therefore it does not show in the radiograph. It was still in place, however, but reduced to a very small size, actually a flat disc about 7 mm in diameter. From side to side it was only as thick as twice the wall of this part of the bladder. In its uninflated state, because of the elastic nature of the tissue, the walls are considerably thicker than the stretched wall of the anterior chamber.

The kidney grew down and in, posterior to the now functionally one-chambered swim bladder (Pl. I, Fig. 2) and enveloped the collapsed second chamber. While it would be difficult to prove, it would seem that the kidney had undergone some hypertrophy, a feature not unexpected in view of the tremendous amount of physiological work it must have been called on to do during the period of healing. At that time the problem of water balance must have been tremendous, as it must be in such aquatic animals whenever there are extensive lesions.

Evidence of the completeness of the recovery is indicated by the large development of the ovaries. These were quite ripe and there is some evidence that a small amount of spawning had already taken place. However, at no time was there noted any behavior suggestive of such activity.

Considering only the extreme cases of this kind of accident, those in which nearly all of the post-coelomic part of the fish has been removed, there may be included besides the present case that of an *Esox lucius* (Hofer, 1901), a *Trachinotus falcatus* (Breder, 1934) and a *Meuschenia skottowei* (Pope, 1945). The phylogenetic spread of these four does not suggest that any group is more likely to survive such accidents than another, nor is a marine environment differentially favored against a fresh-water environment. It is perhaps worth noting in passing that there is nevertheless a marked limitation as to what fishes would stand any chance of survival at all following such an injury. Whole groups of fishes such as the anchovies are so fragile and sensitive to any physical damage that such survival would be unthinkable. It is surely not accidental that the genera involved in all these cases are just those which are apt to be met with in aquaria, which circumstance is borne upon by the remarks of Breder (1936), who discussed the reasons for the presences and absences of the different groups of fishes on display in public aquaria.

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EXPLANATION OF THE PLATES

Plate I

Fig. 1. Lateral view of tailless goldfish. × 1.2. Prior to preservation.

Fig. 2. Dissection of the formalin-preserved specimen showing the fully developed ovary and the apparently hypertrophied kidney. The dark mass just below the vertebral column is the part of the kidney which has descended and filled the space on the left side of the flattened second chamber of the swim bladder. A similar lobe is present on the other side of the bladder. The inflated first chamber may be seen just anterior to the kidney lobe. Below this the large ovary reaches the length of the body cavity just above the partially visible digestive tract.

Plate II

Fig. 3. Radiograph of tailless goldfish, showing change in the swimbladder, including the disappearance of the posterior chamber.

Fig. 4. Radiograph of a normal goldfish of comparable size, with the posterior chamber of the swimbladder intact. The curved line indicates the points through which the bite passed.